

# Hearing Health Risk in a Population of Aircraft Carrier Flight Deck Personnel

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This study evaluated the risk to hearing health associated with duty on the flight deck of a Nimitz class aircraft carrier. Descriptive data includes time-weighted average noise exposure and an evaluation of temporary threshold shift for a group of nonaviator flight deck personnel (FD), and a comparison of accrued permanent threshold shift among three shipboard occupational groups that had been matched for years of military service. The study participants included 76 FD personnel in a high-exposure group, 77 engineers in a moderate-exposure group, and 52 administrative personnel who were considered to have low occupational noise exposure. The study found a mean FD time weighted average of 109 dBA over workdays averaging 11.5 hours. Only 2 (4%) of 52 administrative personnel had any appreciable hearing loss (defined as worse than 20 dB at any frequency 1,000 through 4,000 Hz), whereas FD and engineers demonstrated 17% and 27% hearing impairment, respectively.

## Introduction

Occupational noise exposure is a pervasive health risk within the Navy and Marine Corps, with an estimated 350,000 military and civilian personnel routinely exposed to hazardous workplace noise. In 1995, Wolgemuth et al.<sup>1</sup> noted a 29% incidence of hearing threshold shift among more than 12,492 file audiograms from Atlantic Fleet Sailors. We previously reported that 18% of 54,057 file audiograms demonstrated significant threshold shift and that Navy male sailors developed hearing loss at a faster rate than civilians in similar age groups.<sup>2,3</sup> Exposure to hazardous noise has been associated with a variety of military-specific occupations. An aircraft carrier flight deck during flight operations is perhaps the single most noise-hazardous work environment in the Department of the Navy. Dozens of personnel work in close proximity to multiple aircraft generating 140 dBA or more of recurring noise during workdays that may exceed 14 hours. There has been no focused evaluation of hearing health risk among flight deck personnel (FD), although a 1973 Technical Memorandum reported that the flight helmet

(with incorporated earmuffs) provided adequate protection against aircraft noise of that era.<sup>4</sup>

## Background

The purpose of this study was to determine whether FD are at greater risk of developing a hearing loss than selected other occupational groups aboard a Nimitz Class aircraft carrier. All FD wear headgear called "cranials," which include earmuffs with a noise reduction rating of 23.<sup>5</sup> Current occupational health and safety policy for Navy Forces Afloat requires double hearing protection when noise environments exceed 104 dBA.<sup>6</sup> Navy Medical Department policy estimates 30 dB of protection from double protection, suggesting the probability of overexposure in sustained 140 dBA environments. The combination of extended workdays and persistent overexposures predicts a high incidence of hearing loss among FD.

## Methods

All data were collected during two at-sea periods of carrier qualifications in the summer of 2000 using a protocol approved by the Institutional Review Board from the Naval Medical Center Portsmouth Virginia. The carrier qualification operations for new and requalifying pilots provided a robust noise environment for study, with more than 200 launches and recoveries of aircraft daily. FD volunteers were solicited with outstanding cooperation from the ship's Air, Medical, and Safety Departments. Participants were typically aircraft handlers, aviation weapons handlers, aircraft catapult launch crew members, and aircraft refuelers. Participation was limited to those with at least 2 years of service to facilitate identification of possible accrued hearing loss. Each FD volunteer completed a questionnaire and signed a release before participation. The questionnaire solicited information about hearing-related complaints and off-duty noise exposure (e.g., personal listening devices and shooting). Other than four engineering personnel (ENG) who contributed dosimetry and temporary threshold shift (TTS) data, ENG and administrative personnel (ADMIN) were passive participants whose health records provided hearing threshold data for comparison. The study size was limited by the number of experienced FD available. As such, statistical significance was rarely achieved and is not reported.

## Dosimetry Data

Ten Larson-Davis model 705 dosimeters were used, limiting daily participants to that number. FD and ENG volunteers presented at the ship's Medical Department before flight operations began on the day they were to be monitored/tested.

Dosimeters were clipped on each subject's belt, with the mi-

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TABLE I  
SUBJECT DEMOGRAPHICS

	n	Age Mean/Range (years)	Mean Years of Service	<4 Years of Service	>4 Years of Service
FD	76	26.1/19-49	6.6	39	37
ENG	77	27.8/19-47	7.2	34	43
ADMIN	52	28.2/19-46	6.5	14	38

TABLE II  
SUMMARY DOSIMETRY DATA

	Mean TWA	Range TWA	Mean Minutes	Range Minutes
FD	109 dBA	96.1-119.5 dBA	699	203-1087
ENG	92 dBA	79.1-97.7 dBA	502	317-555

crophone (windscreen attached) clipped to the collar at approximately ear level. Participants were cautioned to leave the dosimeter in place all day, including meal breaks, and to report back to Medical immediately after being released from their work stations at the end of the duty day. Dosimeters were turned off at that time, and data were uploaded for later analysis. Seventy-two sets of FD dosimetry data and four sets of ENG data were collected. Data analyzed for the study included the 8-hour time-weighted average (TWA), total minutes the dosimeter was in place (inclusive of breaks), and the approximate interval between noise exposure and post-test. Dosimetry results are presented using the Department of Defense (DoD) standard of an 85 dBA allowable exposure during an 8-hour workday, with a 3-dB time-intensity exchange.<sup>7</sup> Unless otherwise described, data represent environmental readings (unprotected) as opposed to at the plane of the eardrum (protected).

#### Permanent Threshold Shift (PTS) Study

The length of service-stratified FD group was modeled and departmental rosters were reviewed to select subjects for the ENG and ADMIN comparison groups, whose medical records were then reviewed for evidence of noise-induced PTS and instances where hearing thresholds at 1,000, 2,000, 3,000, or 4,000 Hz exceeded 20 dB on the most recent monitoring audiogram. Per DoD instruction, PTS was defined as a persistent deterioration of 15 dB in either ear at one or more of the frequencies 1,000, 2,000, 3,000, or 4,000 Hz or a 10-dB average deterioration at 2,000, 3,000, and 4,000 Hz in one or both ears. For purposes of the study, thresholds of 25 or greater among this relatively young population were considered abnormal. Table I provides a chart showing pertinent demographics for the three groups. Although 77 subjects were initially identified for each group, only 52 of the 77 ADMIN personnel had suitable comparison audiograms because they are not typically enrolled in the Hearing Conservation Program and therefore do not receive annual monitoring audiograms. Within-group data are reported for those with less than 4 years of service and those with 4 or more years of service, enabling a reasonable cohort of more than 30 subjects each.

#### TTS Study

The purpose of TTS testing was to qualitatively demonstrate overexposure (and underprotection) as opposed to quantita-

tively predicting future hearing loss. All testing was manually administered by the first author, a licensed and certified audiologist, using a calibrated portable audiometer. Earphone enclosures were added to improve sound isolation, because the one-man, double-walled audiometric test booth was marginally certifiable at 500 Hz per DoD criteria. Pre-exposure audiograms were administered concurrent with the fitting of dosimeters on the morning of each volunteer's participation day. Postexposure audiograms were administered upon the subject returning to Medical spaces immediately after being released from his/her watch station at the end of the duty day. For purposes of the study, TTS was identified whenever thresholds at two or more of the six test frequencies in each ear deteriorated by at least 10 dB or when at least three thresholds deteriorated by 5 dB (after subtracting the number of thresholds that improved). It is emphasized that this was not a controlled experiment where the postexposure interval could be carefully dictated. An approximation of the interval between the last protected exposure exceeding 85 dBA and post-testing was extracted from the dosimeter's data log.

## Results

#### Dosimetry data

Table II summarizes dosimetry data for 72 FD subjects and 4 ENG, using an 85-dBA damage risk criteria with a 3-dB exchange rate. Figure 1 illustrates 1,087 minutes of dosimetry data for subject 10, an aircraft handler with a TWA of 116.3 dBA. The lower tracing reflects 1-minute equivalent sound levels in dBA. The upper tracing captures unweighted peak sound pressure levels, also in 1-minute sections. Note the recurrent peaks at the instrument ceiling of 150 dB. The data are compressed into 10-minute sections to capture the entire monitoring day.

#### PTS data

PTS prevalence by group is summarized in Table III. FD personnel were slightly more likely to demonstrate PTS than were ENG. Among personnel with 4 or more years of service, ADMIN were approximately one-half as likely to have demonstrated PTS as were ENG, and one-third as likely as were FD. Results of FD participant questionnaires revealed no observable association of off-duty noise exposure with PTS or TTS data.

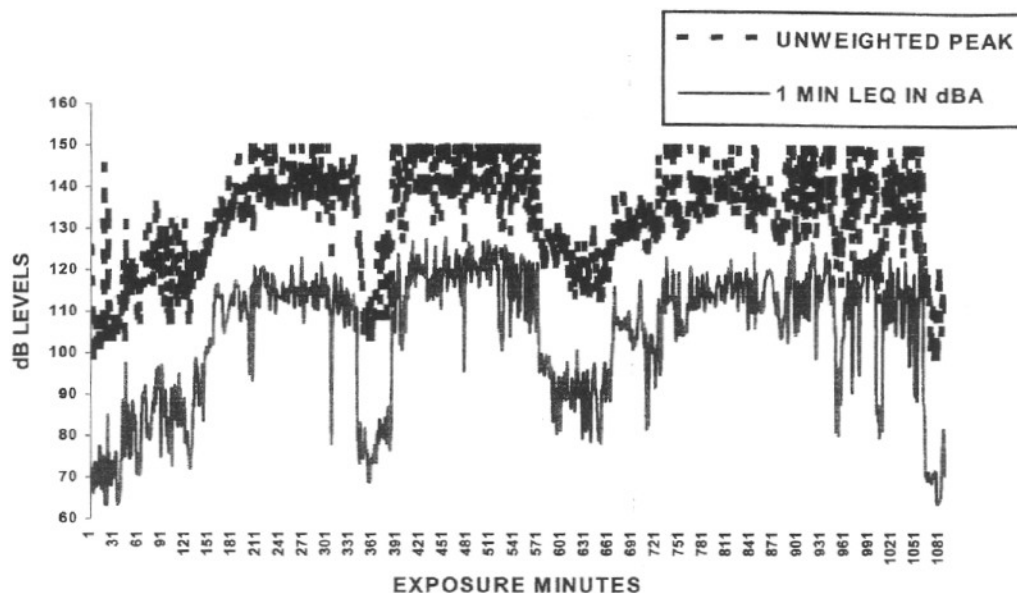


Fig. 1. Dosimetry data, subject 10.

TABLE III  
PREVALENCE OF PTS BY GROUP

	<4 Years	4+ Years	All Subjects
FD	6/39 (15%)	14/37 (38%)	20/76 (26%)
ENG	6/34 (18%)	10/43 (23%)	16/77 (21%)
ADMIN	4/14 (29%)	4/38 (11%)	8/52 (15%)

The prevalence of abnormal hearing (thresholds worse than 20 dB at 1,000, 2,000, 3,000, or 4,000 Hz) is provided in Table IV. Baseline values reflect personnel demonstrating abnormal hearing upon entry into the Naval Service. ENG were somewhat more likely to demonstrate abnormal hearing than were FD, whereas ADMIN rarely developed a hearing impairment.

#### TTS Data

Twenty-two (29%) of 77 FD demonstrated TTS at the end of their duty day. Only 1 of the 22 wore double hearing protection. Time removed from hazardous noise (at the plane of the eardrum) ranged from 11 minutes to several hours, with a mean of 20 minutes. Eighty-six percent of subjects were tested within 30 minutes of noise removal. One of four ENG (TWA 97.3) also demonstrated TTS, occurring in his right ear. He reported that he typically removed his foam earplug from the right ear for occasional telephone use.

#### Discussion

Long duty days and high environmental noise levels pose elevated risk of noise-induced hearing loss among FD. Their risk

may be moderated by the limited number of years that they typically work in that noise environment, and the near-100% compliance with (at least) single-hearing protection. Unfortunately, most FD participating in this study did not wear double hearing protection, perhaps in part because of communication needs, and many demonstrated overexposure. Existing hearing protectors, if worn in a double-protection mode, would almost certainly have reduced the TTS and PTS observed in the study, which is a policy and training issue for this population. Recreational noise did not appear to be a factor in recorded PTS or TTS among FD, as determined by response to a questionnaire. In preparation for the somewhat noisier next generation of military aircraft, the Joint Strike Fighter, the DoD and the Navy are actively investigating various types of improved hearing protectors, including earplugs with incorporated communication receivers, and active (electronic) noise reduction.

#### Conclusions

Although not statistically conclusive, study results suggest an increased risk of hearing impairment among FD and ENG as compared with ADMIN. Markedly elevated TWA noise exposures and inadequate personal protective measures are described. This and other studies suggest the need for elevated and broad-based emphasis on hearing conservation throughout the Navy.

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TABLE IV  
PREVALENCE OF ABNORMAL HEARING

	Baseline	<4 Years	4+ Years	All Subjects
FD	7/76 (9%)	2/39 (5%)	11/37 (30%)	13/76 (17%)
ENG	11/77 (14%)	5/34 (15%)	16/43 (37%)	21/77 (27%)
ADMIN	2/52 (4%)	0/14	2/38 (5%)	2/52 (4%)

Eric Carlson, MSC USN, Industrial Hygiene Officer and Assistant Safety Officer, provided liaison with the various departments, scheduling assistance, and helped to fit dosimeters. Finally, our thanks to the men and women of the Atlantic Fleet who extended their already long duty days to make this study possible.

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